AUGUST 1953

VOLUME 2, NUMBER 8

# Battelle Technical Review

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Thermoplastics for Pipe

# HUNGER FIGHTER

K. Starr Chester

"Scientists have given us the wherewithal for solving the problem of the world's hunger. If only man's social and moral growth could match his technological progress, hunger could be a thing of the past."

K. Starr Chester thus expresses his optimism and concern over our continuing battle against hunger. Through his travels, he knows the seriousness of food scarcities and the value of technical progress. His appreciative words to a Greek youth seeking advice were, "There is no finer way than farming to make your life useful and productive".

Ken is fighting the battle for agricultural progress on a number of fronts. As chief of Battelle's agricultural and biosciences division, he has guided his technological team to such significant research as the ultrasonic splitting of viruses and bacteria for possible use in serums, sterilization of foods by soft X-ray irradiation, development of chemicals for growth control of plants, and the investigation of the food possibilities of algae. Other research on trace minerals, fertilizers, and insecticides and fungicides is helping to increase our food supply.

On other fronts Ken is helping to shape agricultural policies. He is chairman of the research committee of the National Farm Chemurgic Council which has responded to Secretary Benson's request for suggestions on programming chemurgic research in the Department of Agriculture. As chairman of the International Committee on Plant Disease Losses he is mapping a world fight on plant diseases.

Ken's bent toward agriculture was shown in his college days. When offered assistantships both in physics and biology, he chose the latter. His choice led to the study of plant diseases and a Ph.D. in botany from Harvard. Association with the Rockefeller Institute for Medical Research and direction of the Research Foundation at Oklahoma A & M College broadened and deepened his interest in agricultural research and social welfare.

Ken's avocations are varied. He is a keen student of the Russian language. On the lighter side, he enjoys a sort of postman's holiday in his garden, likes to fish, and has complicated chess by helping to develop a three-dimensional game.

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In recent years, the use of thermoplastics in the manufacture of pipe has increased rapidly. The properties of the plastics now limit the possible applications of the pipe. However, the natural advantages of the materials, along with continuing research and developments, indicate that plastic pipe will find many new uses in the future, thus continuing the expansion of production.

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# Small Business and Research

ALTHOUGH LARGE corporations are most frequently associated in the public mind with the dramatic forward steps made in technology, small business today is alert to the opportunities in research. This is shown not alone by the steady stream of new and improved products coming from small companies, but also by the growth of facilities for small business research. These facilities include the laboratories operated by individual companies, the laboratories operated by trade and research associations, and the independent laboratories that cater to the research needs of small business.

A study conducted by the National Association of Manufacturers several years ago showed that 55 per cent of companies with annual sales in the range from $\frac{1}{4}$ million to $1 million maintained laboratories with some type of research function. Even 48 per cent of the companies questioned with sales less than $\frac{1}{4}$ million annually had laboratories that were used in part for research and development work.

Probably even more indicative of the research consciousness of small business is the growth of trade associations. There are now some 2000 trade associations of national and regional scope in the United States and approximately 10,000 of state and local importance. Many of these have research as one of their major functions. Trade associations conduct research intended to promote the trade as a whole, using either their own laboratories or engaging the services of outside organizations. There are at least 30 nationally known laboratories maintained by trade associations.

A substantial portion of the research conducted by small business is channeled through commercial research laboratories, research institutes and foundations, and universities. Numerous testing and consulting engineering services are available to the small business firm on a fee basis, and there are a score or more of commercial laboratories that contract for research projects. Associated with universities are approximately 60 research foundations that serve small business, and operating independently of any parent organization are a dozen or more private research institutes. In any of these laboratories, the small firm can get a well-rounded research study of a given project carried out through the expenditure of from $10,000 to $20,000 a year. For instance, the small business or trade association can obtain at Battelle the services of skilled technologists, working with the most modern research equipment, for as low as $1,000 per month.

The fact that small business as well as large can enjoy the benefits of research is one of the keys to American progress and industrial productivity. It is also one of the best assurances of continuing competition and vigor in our industrial economy. No large company dares draw into a shell of technological lethargy as long as its position is vulnerable to competitive threats from numerous small firms. How much less can small business, with smaller reserves, afford to neglect progress!

It is very significant that small business rarely becomes known for important industrial developments. The reason is that small business invariably becomes big business with the development.

Clyde Williams

President, Battelle Memorial Institute

# Thermoplastics for Pipe

*by* HENRY W. KUHLMANN

*Since his association with Battelle in 1946, the author has been engaged in plastic and adhesive research for utilization in specific products. Earlier, he had served as technical supervisor with the Plaskon Division of the Libby-Owens-Ford Glass Company. A graduate of the Missouri School of Mines, Kuhlmann is a member of the American Chemical Society and the Society of Plastic Engineers.*

ONE OF THE large-volume markets for thermoplastics is industrial piping, but possible applications in this field have scarcely been tapped. Until recently, cold-water supply systems, irrigation and farm watering systems, and deep-well piping have been the chief consumers of plastic pipe. More recently, such pipe has been used for the transmission of natural gas and crude petroleum products. Active studies are being made for many other industrial applications.

Plastic pipe has certain general advantages. It has, in general, better corrosion resistance than does pipe made of iron, steel, copper, and brass. It carries more fluid for a given size than does steel pipe because of smoother interior surfaces. Plastic pipes are lighter in weight. Some are flexible, which makes them easy to install. The use of insert couplings with clamps and solvent-welded joints also simplify installation. Coupling problems still exist, however, as will be pointed out later.

The available sizes of plastic pipe vary with the use and the material. The more common sizes of extruded pipe range from one-half inch to six inches in diameter to correspond to the usual standard and extra-heavy iron pipe. Polyethylene pipe is in largest demand in the one-inch size range for home water-supply systems. The tremendous impetus of suburban developments and farm-water systems has been a major factor in this application.

The first year of real production of plastic pipe was in 1951, when an estimated 11.5 to 12 million pounds of resin was used in producing some 30 to 35 million feet of pipe. In 1952, 18 million pounds or 70 to 75 million feet of pipe was produced. Polyethylene pipe accounted for 10 to 12 million pounds of this production. It is predicted that by 1960 some 75 million pounds or 450 to 500 million feet of pipe will be produced. This is a comparatively small amount when compared with some seven million tons of steel pipe and 1.5 million tons of cast iron pipe produced in 1951.

Steel companies are aware of the possible inroads of plastics. One company has already installed an experimental plastics extruder unit to determine production techniques and cost data. However, the steel pipe companies are said to favor plastic coating of steel pipe. Such coatings are reported to withstand higher temperatures than do solid plastic pipe. This is readily understood when the factor of creep is taken into consideration. However, the cost of coated pipe is more than twice that of steel pipe. Coupling problems of coated steel pipe are somewhat more complicated than those of solid plastic pipe.

While plastic pipe costs more than galvanized steel pipe, producers of flexible plastic pipe claim the lower cost of installation more than offsets the initial costs. The pipe industry lacks service information on plastic pipe, and until industry-wide standards are provided, the major application will be limited to the relatively few specialized, although comparatively large, volume applications.

The weaknesses as well as the strong points of plastic pipe are generally known. Although some generalizations are possible, each use of the pipe presents a specific problem. Therefore, it is advisable to examine the individual thermoplastics used in production of pipe.

## POLYETHYLENE

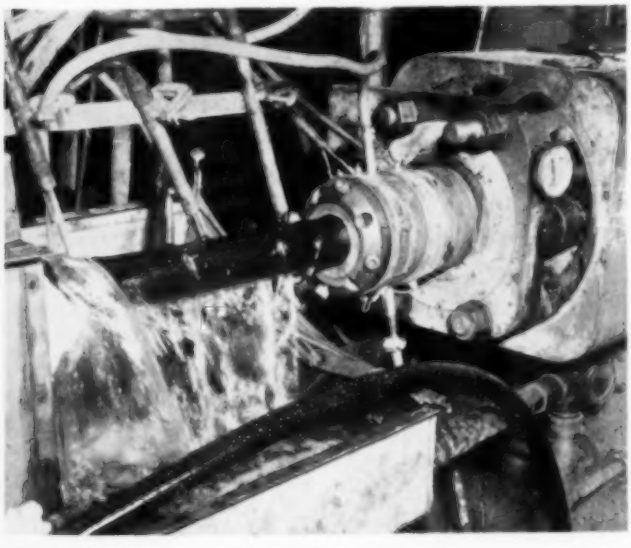
Polyethylene accounts for more than half the present production of plastic pipe. The lightest of the commercial plastics, it is only about one-eighth as heavy as galvanized iron pipe. Although its tensile strength is the lowest (1500-1800 psi) of any of the plastics used for pipe, its impact strength is the highest. Because of its flexible nature, compressive and flexural strengths are not important.

The water and corrosion resistance of polyethylene is excellent. The pipe is virtually unaffected by all inorganic solutions (acid, alkali, or salt) except high concentrations of oxidizing acids. While it has good resistance to most organic solvents, hot aromatic hydrocarbons dissolve it, and polar organic solvents such as acetone and alcohol cause stress cracking. Consequently, applications, where contact with organic solvents are contemplated, should be studied carefully before installations are made.

Users of polyethylene pipe take advantage of its light weight, flexibility, high impact resistance, and resistance to corrosion. Its nontoxic, tasteless, and odorless characteristics make polyethylene desirable for use in food and beverage processes, cold-water systems, and livestock-water installations. Use in mine drainage, sewer and water-disposal systems, radiant-heating systems, and irrigation are large-volume or potentially large-volume applications. The ability of this plastic to withstand freezing temperatures without damage is important in some of these installations; for example, water lines may be left unprotected in freezing weather. The accepted upper temperature limit at the present time is 110 F to 120 F. Some radiant heating installations have been made using water at 110 F.

### Styrene Multipolymer

The most common copolymer types are styrene-butadiene and styrene-acrylonitrile or multipolymers of all three monomers. Most of the pipe made from this class of materials, however, is of the shock-resistant or rubber-modified type. These are made by compounding various proportions of polystyrene of styrene copolymer with 10 to 25 per cent of a rubber. Higher rubber content makes extrusion more difficult, and thus eliminates such material from consideration for plastic pipe.



***EXTRUSION OF POLYETHYLENE PIPE.** As the pipe emerges from the discharge end of the extruder, it is cooled by cascading water before passing on to the conveyor. (Courtesy of Yardley Plastics Company)*

This group of materials has a wide range of physical properties. It is in the very lightweight range, being only slightly heavier than polyethylene. At the same time, it is more heat resistant and stronger than polyethylene. It has a useful temperature range up to 150 to 170 F, and has a tensile strength of 7000 to 12,000 psi. The water absorption of the modified styrene plastics is generally quite low. They are essentially hydrocarbons, and burn at a moderate rate. The effect of sunlight and aging varies but is generally insignificant.

The chemical resistance of this group, especially toward organic solvents, varies more widely than does any other plastic used in pipe. The mechanical and chemical properties of this group also vary so that the raw material manufacturers should be consulted before selecting a compound for a specific use.

Both solvent-welded and threaded joints may be used. The preference, however, is for solvent welding. The material is frequently used for molded fittings for other types of plastic pipe, notably for polyethylene. Allowable working pressures vary. One fabricator indicates working pressures as high as 350 psi for one-half-inch pipe, but he states elsewhere in his brochure that safe working pressures are limited by the fitting method employed. Cemented and threaded joints are generally not useful over 125 and 200 psi, respectively.

This group of plastic pipe is used in mine-water disposal, irrigation, rural-water systems, sprinkling systems, and for sewage handling. While some of the modified polystyrenes are not suited for petroleum applications, those modified with acrylonitrile are usually satisfactory.

### Cellulose Acetate-Butyrate

The applications of this plastic are much the same as for the modified polystyrenes in the semirigid and and rigid fields, although its specific gravity is slightly higher, with a range of 1.14 to 1.22. The tensile strength of the types recommended for pipe ranges from 6000 to 3600 psi over a temperature range of 77 F to 158 F.

The impact resistance of acetate-butyrate is higher than that of the rigid vinyls and Saran. Aging has only a slight hardening effect and resistance to sunlight is excellent if carbon black is incorporated. Water adsorption is higher than that for other plastics used for pipe. Weak acids and alkali have no effect, but strong acids

and alkali decompose the material. Hydrocarbons have little effect on this pipe, but alcohols soften it, and ketones and esters dissolve it. Although cellulose acetate-butyrate burns slowly, at least one producer reports a self-extinguishing product. This is made possible by the use of phosphate-type plasticizers and additives such as antimony trioxide.

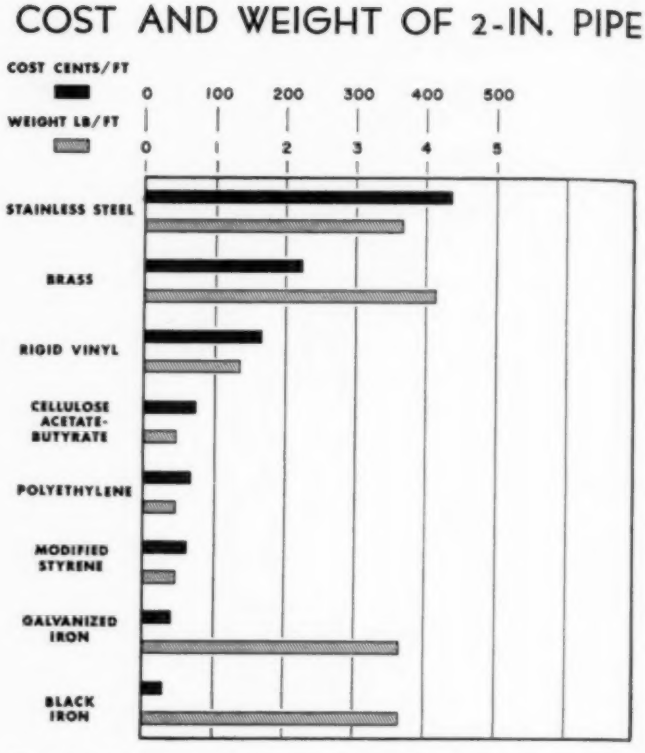
The largest application for butyrate pipe is in the oil fields where it is used to transmit brine, crude oil, and natural gas. It is especially suited for transmission of paraffin crudes since the paraffins falling out of solution do not cling to the smooth walls and clog the pipe as in the case with metal and cement pipe. There are no electrolytic corrosion problems with butyrate pipe. It should be buried, however, for protection against weathering and mechanical damage. The pipe may be used for gas service lines, both new and replacement. In many replacement applications, the old corroded metal line is used as a conduit. The new smaller diameter butyrate pipe can be pushed through the metal pipe, thus minimizing the damage to streets, sidewalks, and lawns, and reducing installation costs.

Irrigation and drainage systems for farm and industry make good use of butyrate pipe. It is well suited for jet-well and suction installations. The food-processing industry is especially interested in its use because the pipe can convey citrus juices, wine, beer, and brine solutions. Another advantage is that butyrate pipe is available in transparent form, thus allowing inspection of flow.

### Polyvinylidene Chloride (Saran)

Polyvinylidene chloride and its copolymers (Saran) were among the first plastics to be used for pipe. Initially, they were used for pipe linings, in cases where pressures and temperatures exceed the safe limits for unsupported plastic pipe. Saran has the highest specific gravity (1.65 to 1.72) of all thermoplastic used in this field. Water absorption for 24-hour immersion is less than 0.1 per cent. The tensile strength ranges from 3000 to 5000 psi, and the plastic can be used at temperatures up to 170 F. Moreover, Saran has good electrical and thermal-insulating properties and will not burn.

Chemical resistance of the material is excellent because neither strong nor weak acids or alkalis, except strong ammonia solutions, have any appreciable effect on it. It has good resistance to most organic solvents except some ketones, esters, and chlorinated hydrocarbons. However, resistance to corrosive liquids and organic solvents decreases with increasing temperature. Saran is only slightly affected by sunlight, and darkens only slightly on outdoor aging. It can be hot-gas welded, and the welded joints are substantially as strong as the other portions of the pipe. The material is not recommended for uses requiring shock resistance or flexibility at sub-freezing temperatures.




*The chart shows the comparative initial costs and weights of 2-inch pipe manufactured from a variety of materials. The data are from the PMPC Report.*

Saran piping finds large application in the chemical industry where corrosion is a serious problem. In many cases, it has replaced such corrosion-resistant metals as copper, stainless steel, and aluminum. It is used for carrying electroplating solutions, hypochlorite solutions, hydrofluoric acid, sulfuric acid up to 60 per cent concentration, and many others.

### Rigid Vinyls

Rigid vinyls are available in several compositions which are usually copolymers of vinyl chloride or low-molecular-weight vinyl chloride homopolymers. They are strong, having tensile strengths of 6000 to 9000 psi. They have excellent chemical resistance to all concentrations of acids and alkalis, but not to oxidizing acids, or to such organic solvents as ketones, esters, and chlorinated hydrocarbons. The specific gravity of these materials varies from 1.35 to 1.45. The recommended upper continuous operating temperature for these materials is 130 F, but they can be used to temperatures as low as —70 F without appreciable changes in physical properties.

Rigid vinyls have been used only recently for pipe in this country, although Germany made extensive use

of them during World War II. Bursting pressures of over 1700 psi for one-half-inch pipe have been reported. However, working pressures of only 150 psi have been advocated by some cautious fabricators, while other recommendations reach as high as 500 psi. Standard fittings are plunger or injection molded.

Aside from corrosion resistance, the most important feature of rigid PVC pipe is its strength. For industrial piping, it is strong enough to support its own weight so that conventional installations can be made, thus eliminating external channel supports such as are required by some plastic pipe. Many industrial applications are projected, including chemical piping, electroplating equipment (sheet stock can be used to fabricate tanks and other equipment by welding), heat exchangers, and others requiring high strength and a high degrees of resistance to corrosion.

Of considerable importance to the increased use of rigid PVC pipe is the recent extraordinary price reduction. A recent price list from a fabricator gives a reduction from the $1.65/foot for two-inch pipe in 1951, to $0.60, which is about the same price as for flexible polyethylene pipe.

### Problems in Plastic Pipe

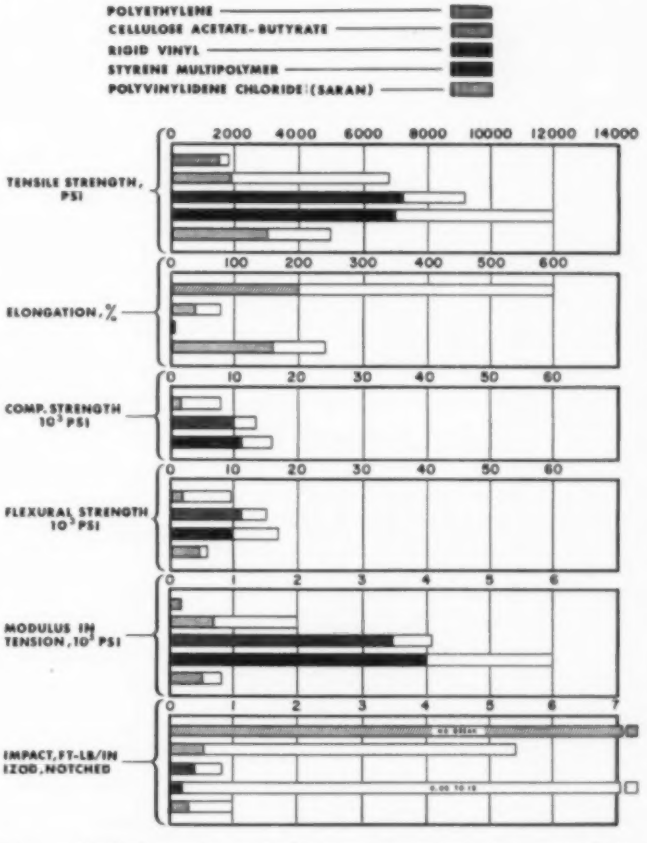
The two major problems confronting the plastic-pipe industry are (1) lack of industry-wide standards, and (2) cost. There are at present no widely accepted standards. Reduction in costs is certain to be linked to costs of (a) raw material, (b) production, and (c) distribution. Reduction in costs of rigid vinyls has been the most marked. Reduction in costs of polyethylene have been predicted for several years, but it appears that any sizeable cost reduction will have to wait until the proposed new competitive production facilities for polyethylene are realized. Some new plants are expected to be in operation by the end of 1953, and others late in 1954.

Reported strength data vary widely as do data for temperature and chemical resistance. Lack of this standardized information leads to confusion for the consumer. The wide variety of types of plastics serving virtually identical markets leads to duplication. It has been reported than one oil field consumer refused to consider any plastic pipe because he already had too many varieties of metal pipe.

Another problem of considerable concern to some fabricators is that of scrap or re-worked plastic. There are two schools of thought on this question. The users of scrap and re-worked materials feel that as long as the product meets their specifications and the specifications are clearly stated, there should be no cause for complaint. Virgin-material users, however, feel that the use of scrap and re-worked materials adds to the general confusion existing in the industry, and can lead to trouble where consumers make careless substitution. Some extruders of flexible pipe make both grades. The grade using scrap or re-worked material is labeled not for human use or for use in livestock-watering systems. Perhaps the trend toward "molded in" identification will help clarify this point. But since it is impossible to pressure test every length of extruded product, a poor selection of scrap or a poorly compounded blend of scrap with virgin material could bring about disastrous results and give plastic pipe a black eye.

Another major problem confronting the plastic-pipe industry is the matter of fittings. Most fabricators of flexible pipe, especially of polyethylene, advertise the ease with which connections are made, but none the less, practically all use internal fittings for this material. These fittings are molded of styrene multipolymers, and the pipes are joined with stainless steel clamps around the pipe and fitting. Such fittings cannot help but reduce the flow in the pipe, especially in sprinkling systems which use a large number of such

## PROPERTIES OF THERMOPLASTICS


POLYETHYLENE
CELLULOSE ACETATE-BUTYRATE
RIGID VINYL
STYRENE MULTIPOLYMER
POLYVINYLIDENE CHLORIDE (SARAN)
TENSILE STRENGTH, PSI
0 2000 4000 6000 8000 10000 12000 14000
ELONGATION, %
0 100 200 300 400 500 600
COMP. STRENGTH $10^3$ PSI
0 10 20 30 40 50 60
FLEXURAL STRENGTH $10^3$ PSI
0 10 20 30 40 50 60
MODULUS IN TENSION, $10^3$ PSI
0 1 2 3 4 5 6
IMPACT, FT-LB/IN IZOD, NOTCHED
0 1 2 3 4 5 6 7

***The unshaded portions of the bars represent the spread in values to be found in commercial materials. The data used here are based on ASTM testing procedures. In some instances, applicable data were not available.***

fittings. Much work has been done on the design of compression and external sleeve-type fittings, but none have proved completely satisfactory. Design of an easy-to-use external fitting is sorely needed.

Creep is another problem which concerns plastic-pipe fabricators and consumers. This is a property of all materials and is especially important in thermoplastics that exhibit a high degree of elongation. No creep data for plastic pipe have been reported in the literature. This factor could be extremely important in applications where pipe is used in above ground applications, especially in hot climates.

Still another cause for concern in plastic-pipe installations is "water hammer", or shock loading, as a result of fast-closing valves. It has been demonstrated that surge pressures as high as ten times the static pressure can be developed, and that the peak pressure is a function of the speed of valve closing. Since there was a time when fabricators recommended operating pressures as high as 60 per cent of the bursting strength, it is easy to see why failure sometimes occurred as a result of water hammer. Reductions in maximum operating pressures have been generally applied. Cooperating with plumbing supply manufacturers to make slower closing automatic valves should eliminate this troublesome problem.

Plastic pipe is expected to show considerable increase in sales, particularly in fields where limitations of temperature and pressure permit its use. Tests scheduled for completion by the end of 1953 by the National Sanitation Foundation will indicate the nontoxicity or toxicity of various types of plastic pipe. When this information becomes available, greatly increased application in municipal and rural water systems in anticipated.

Developments in thermoplastics to permit higher temperature applications are indicated. Such materials would be a definite boost to applications in the chemical-processing field. Reference has been made to such a material having high impact strength, and being useful at temperatures to 400 F.

Production of plastic valves has lagged behind other phases of plastic-piping development. This is due largely to the fact that the demand has been lacking. In such major installations as water, drainage, and irrigation systems, brass valves have been satisfactory. The need for valves having better resistance to corrosion is certain to arise, however, in chemical and industrial piping installations. Saran diaphragm-type valve bodies, Saran-lined metal valves, and a polyethylene valve using packing rings of a polyethylene-polyisobutylene mixture are reported. The cost of such valves is high, and is expected to remain high until demand becomes sufficient to warrant large-scale production. It is the opinion of fabricators that valves from plastic components can be produced when the need arises.



"Gottfried Keller first attempted to make paper out of wasp's nests. He failed, but one evening while strolling about the village he came upon a group of children intently gathered around a grindstone. One sturdy boy was whirling the crank; the others were taking turns pressing cherry pits against the revolving stone (with a board) in order to grind in each a tiny hole. It was, in fact, a cooperative enterprise in the manufacture of cherry-pit necklaces . . . The revolving stone passed in its lowest circuit a trough of water upon which floated a thick layer of pulverized wood and cherry stones. Keller scooped up a handful of this woody scum and pressed it to squeeze out the water. It became a pulpy mass which, as he kneaded it between his fingers, reminded him of the rag pulp that Heinrich Voelter (a papermaker) turned into paper. He hurried off to his comrade, and next morning they were at it again, experimenting. Out of those experiments came cheap wood-pulp paper."

William Haynes in *The Scientific Monthly*

# Meeting U.S. Needs for Electric Power

*by* PAUL G. PERRY

*Before and after World War II, the author had experience in practically every phase of the electric power industry. After serving in various engineering capacities with the Texas Power and Light Company, he supervised electrical installations in ships for the Navy in the great San Francisco Bay area. During World War II, Perry directed electrical installations at advanced bases in the Pacific and later helped plan new bases. He also took part in planning postwar perimeter defense bases. Since joining Battelle in 1949 he has directed research on electric power and other problems.*

THE ELECTRICAL utility industry occupies a key position in our national economy which supports the highest standard of living of any nation in the world. With less than 7 per cent of the world's population, we are now producing approximately 45 per cent of the world's total electrical energy output.

Within the relatively short span of a man's lifetime the industry has become a $25 billion enterprise, composed of both private and publicly owned and operated properties. Since the turn of the century, electrification of all phases of modern life has continued at such a rapid rate as to tax the ability of the continually expanding power generating, transmitting, and distribution facilities of the nation to meet the ever increasing demand.

Ninety-three per cent of power installations in industry are now electrical as compared with 31 per cent 40 years ago. Of all farm homes, 90 per cent now receive central station electrical service as compared to 14 per cent in 1935. The average cost of electrical service to residential and farm homes has been reduced from 7.4 cents per kwh. in 1921 to 2.8 cents at the present time, despite severe inflation in recent years. Electrical power output in the United States has doubled approximately every 10 years since 1900, and it reached a total of over 400 billion kwh. in 1952. However, as phenomenal as past progress has been, the end to expansion is by no means in sight.

According to the report of the President's Materials Policy Commission, the nation will need 1400 billion kwh. of electrical energy by 1975, or approximately 3½ times the 1952 output. Such increases will result from the nation's expected population and industrial growth. As in the past, the intangible force that will make the expansion possible will be the electrical utility industry's own vision and progressiveness.

The Nation's public and private electrical utility facilities had installed generating capacity of approximately 82 million kilowatts by the end of 1952. Ownership of this generating capacity is 78.6 per cent private, 11.5 per cent federal, and 9. 9 per cent local public properties. The 400 billion kwh. 1952 production from this capacity was divided among the interests, 80.8 per cent private, 13.0 per cent federal, and 6.2 per cent local public properties.

The many thousands of miles of outside plant consisting of transmission and distribution lines, switching stations and substations, and other control facilities must be improved and expanded as new capacity becomes available. These facilities are vital to the utilization of the energy, and represent well over half of the total capital investment and require more than half of the maintenance expenditure. Transmission lines (22 kv to 287.5 kv)—for carrying bulk power to load centers—totaled more than 275,000 circuit miles in 1952. Total distribution line—for delivering power to users—mileage figures are not available for the privately owned systems. However, REA alone had 1,240,000 miles of line in service by the end of 1952 and this was largely in the distribution category.

## PLANNING FOR FUTURE NEEDS

The increases in national electrical demands have required farsighted plans and vigorous construction programs. Construction totaling $3.7 billion was completed in 1952. Private interests executed $2.6 billion or 70 per cent and the federal government some $700 million or 18 per cent. The remainder was made by local public interests. The 1953 construction program is scheduled at $4.2 billion or a 12 per cent increase over 1952. Construction goals in the past have been delayed by shortages in critical materials; however, the increased importance attached to this vital industry has improved its priority position on the critical material

list. As a result, in spite of the enlarged needs, it should be possible to accomplish the program.

The modern electric utility draws on every media at its disposal in order to predict the future demands on its system as far in advance as possible. The daily load curves are continually studied to develop realistic annual and seasonal growth trends. These, in addition to very active participation in all manner of public relations functions, are used to make and execute realistic expansion plans on a two-, five-, and ten-year basis. The electrical utility industry is somewhat in a class by itself in that the future conditions must be adequately provided for in advance of actual demands if the territory served is to attract, hold, and provide for expansion of industries of all kinds. The utility has to plan permanent facilities of a substantial nature at relatively high cost which must be capable of reliable service under future demands. The utility does not sell kilowatt-hours, but 'round-the-clock service on demand, as interruption-free as it is possible to make it. Kilowatts are only a means of measuring the amount of service rendered.

## Growth of the Industry

Some aspects of the phenomenal growth of the electrical industry may be apparent when it is realized that 1.5 million new customers were added in 1952, bringing the total to 48.5 million. This addition has continued at an annual rate of approximately 2 million since 1945. Since 97 per cent of all the Nation's homes now have been electrified, the yearly addition of new customers is expected to decrease. However, the use of electricity per customer is increasing, and during 1952 reached an average of 2175 kwhr. Consumption by residential customers increased 13 per cent in 1952 to a total of 87 billion kwhr. All manner of electrical appliances for the American home are being manufactured and sold to the public, and average increases in consumption are predicted to be approximately 5000 kwh. by 1975. Industrial consumption increased 6.1 per cent and commercial consumption increased 8.5 per cent in 1952.

Total electric power facilities increased 9.3 per cent in 1952, which is slightly under the rate necessary to double them every 10 years. The lag is largely due to nondelivery of critical materials.

The delivery of electrical energy has been greatly aided by improvements in electrical converters, transformers, and transmission lines. Generating systems have been expanded in capacity and made more efficient by research developments in metals to withstand higher temperatures and pressures, by more effective methods for heat transfer, and by better methods of combustion to increase the efficiency of fuels.

Privately owned and operated electrical utilities, in their position of leadership, are now going far beyond the job of developing the maximum potential for established uses of electrical energy. They are actually conducting studies to shorten the period of time between research on new uses and their practical application. By being closer to such developments, the industry is thus in a better position to plan more accurately for meeting future increase in demand. An outstanding example of this foresight is its project, in cooperation with the coal industry, to determine the possibility of large-scale expansion in the present production of low-carbon steel in the basic arc furnace. Such an achievement would bring greater consumption of electricity. In turn, this would mean more use of coal, thus conserving oil for other purposes. Until recently, electric furnaces have produced mostly stainless and other high-alloy steels, the production of which, incidentally, rose from 2.9 million tons in 1941 to 7 million tons in 1951.

Among commercial consumers, more air conditioning, widening use of lighting for display and advertising, and better methods of heating, especially by use of the heat pump, will contribute to expanded demand. Further electrification of railroads also will require increasing amounts of electrical energy.

Noteworthy growth trends are seen in many industries, particularly in the chemical and metallurgical industries, which are the largest consumers of industrial electric power. The high-energy-consuming aluminum and magnesium industries are planning on rapid growth. As the new titanium industry expands in the next decade, it will account for a sizeable increase in energy requirements. More power will be needed to process low-grade iron ores for the steel industry. In the chemical field, plastics, synthetic fibers, phosphorus, calcium, and chlorine show important growth prospects.

The atomic energy program consumes huge quantities of electric power. This relatively new market for electric power will expand rapidly as new plants are completed.

The electric power industry has a unique 75-year record of progressiveness in initiating and benefiting from research developments that can improve the production, transmission, distribution, or consumption of its product. More than any other single factor, this progressiveness assures us that the industry will continue its outstanding leadership in meeting the seemingly limitless demands for power in the American economy.

# Notes From Battelle

## IRRADIATION OF FOODS

Interest in the possibility of sterilizing foods by some form of irradiation is growing rapidly. Technologists working on the problems related to this development believe that radiation sterilization will soon be a reality in commercial production. At the same time, they warn that a great deal of study, both general and specific, must be carried on before the process can be applied to many individual products.

Radcliffe F. Robinson of Battelle, who has carried on investigations in the irradiation of foods and drug products, recently reported on the status of irradiation research. He told members of the Ohio Valley Section of the Institute of Food Technologists they must not expect ionization sterilization to solve all their food-processing headaches. At the same time, irradiation holds great promise for those patient enough to work out the solution to their problems.

Preservation of food by irradiation may be carried on by three methods. Both hard and soft (produced at 150 kv or less) X-rays have proved effective for the purpose, though the latter are more readily absorbed and can be produced at lower costs. Cathode rays, or artificially accelerated electrons, are another possible source of irradiation. The third source, atomic-fission waste products, may be a practical source if they are made available at low cost.

The problems faced by those interested in sterilization by irradiation are already being attacked by scientists. Investigations are being carried on concerning the chemical changes in food that are produced by irradiation. These side effects may appear as changes in flavor, color, or texture of the food. Studies are also being made of the effect of irradiation on the storage life of various products, including late appearances of side effects and perhaps toxicity. Research is also needed on types of packaging best for irradiation and the volume of the product best suited for such processing.

The advantages of sterilization by irradiation, however, make the research well worth while. Gains from the process might be considerable through the elimination of heat damage since there is almost no temperature rise in the radiation sterilization. Elimination of heat in the processing would also permit the use of more economical packaging materials. Irradiation would also greatly increase the efficiency of food production. Continuous production lines could replace the present batch operations, resulting in the reduction of space and labor requirements and, at the same time, speedier production. An additional advantage is the fact that some irradiated foods require no refrigeration, thus reducing the cost of preservation.

## STUDY OF SALT-BATH CORROSION

Salt baths for heat treating metals have become increasingly popular in recent years. Among their advantages for the heat treaters are the reduction of thermal shock through an insulating layer of frozen salt, uniform and rapid heat transfer, and protection of work from scaling. Though salt baths are used for the protection of metal being treated, they tend to corrode the high-alloy pots and other equipment used for the heat-treating process.

The Alloy Casting Institute recognized the problems facing those concerned with salt-bath processes and authorized a research program on the subject at Battelle. The aim of the program was twofold. One purpose was to classify cast stainless alloys according to their corrosion resistance and, if possible, to modify the alloys to increase their corrosion resistance. The other purpose was to evaluate salt mixtures, additions, and operating variables according to their corrosive effects on the cast alloys.

The investigation disclosed that the corrosion of the alloy pots was largely by intergranular attack. A study was made of the resistance of 65 cast iron-nickel-chromium alloys of different composition to corrosion in five commercial heat-treating salt baths. Battelle technologists, directed by J. H. Jackson and M. H. LaChance, found that the resistance of HT(15% Cr—35% Ni) and HW(12% Cr—60% Ni) alloys to corrosion could be increased by reducing their carbon content from 0.50 to 0.08 per cent. They also found that an alloy of 17 per cent chromium, with little or no nickel, will perform better than higher alloys in chloride-type baths containing little carbonate. Such modifications may lengthen the life of alloy pots from 1½ to 5 times. The lower strength of low-carbon or straight-chromium alloys, however, may call for redesigning of equipment. Furthermore, some foundry difficulties are encountered in the production of these particular alloys.

The study also revealed that sludge at the bottom of the heat-treating pot tends to increase corrosion markedly. On the other hand, variations in salt baths, rectifiers, and ordinary heat-treating procedures were found to affect alloy corrosion by less than 25 per cent.

## STUDY OF VERTICAL GATING

Improved gating systems for molds have been a subject for investigation at Battelle for the American Foundrymen's Society for some time. In this connection, a new technique was developed for the study of horizontal gating which involved motion-picture studies of the action of water in transparent molds. The technique is now being employed in the study of vertical gating systems.

In a recent progress report to the Light Metals Research Committee of the AFS, K. Grube, J. G. Kura, and J. H. Jackson presented developments in their study of vertical gating. This phase of the research program, now in its preliminary stages, is directed toward a study of conventional, vertical gating systems used in small and large models. Thus far, they have found that sprues with rectangular cross sections that enter the bottom of the casting seem to be preferable for vertical gating of simple plates made in small molds. For heavier plates, made in large molds, a tapered sprue offers advantages. In general, research to date indicates that the tapered sprue permits higher flow rates with a minimum of turbulence.

## SELECTION OF MATERIALS

The rapid increase in the number of available materials has complicated the manufacturer's problem of of choosing the best material for a particular product. The factors involved in selection have been discussed by Leo C. Bailey and Richard J. Lund in the May issue of *Materials and Methods*. Their article, "How Economic Factors Influence Materials Selection," points out that the process of selection may be expensive and time-consuming but that it is nevertheless worth while.

According to the authors, the broad factors that must be considered in choosing materials include: their engineering properties; their costs of production and fabrication; their attractiveness to the consumer; and their availability as a result of stockpiling and government controls.

An interesting analysis of some of the market factors emphasizes that customers are concerned primarily with performance standards rather than materials. However, color and shape play an important part where consumer products are concerned. Because of our aging population, increasing employment of women, and rising production costs, the factor of lightness is becoming increasingly significant. Greater public awareness of waste from corrosion is prompting manufacturers to consider corrosion-resisting materials. Finally, the trend to "do it yourself" and other developments looking toward easier maintenance may also influence the design, and hence the materials, of many products.

## U. S. GOVERNMENT RESEARCH

The National Science Foundation has released estimates of obligations and expenditures for research by Federal agencies. The agencies spent a total of $1839 million on research and development during the fiscal year 1952. The estimate for 1953 is $2189 million, while the President's budget for 1954 set aside $2327 million for the same purposes.

The 1952 total was distributed among Federal agencies as follows: 72 per cent for the Department of Defense; 14 per cent for the Atomic Energy Commission; 4 per cent each for the National Advisory Committee for Aeronautics and the Federal Security Agency; and 6 per cent for 20 other agencies.

## FUELS AND ENERGY RESEARCH

All industrial processes require the expenditure of energy, and its cost affects the economics of each operation. Usually this energy cost is not great, but frequently it is a limiting factor that dictates what progressive steps a company can make. Any research that increases the availability and lowers the cost of energy helps the progress of a company or an entire industry and the Nation's economy as well.

Research on energy may take many forms. It may include increasing the supplies, reducing the costs, and advancing the efficiency and utilization of such conventional energy sources as petroleum, coal, natural gas, and electricity. Such research may also aim at developing such unconventional sources as atomic energy, solar energy, wind power, and heat from the earth.

Research aimed at giving industry more energy at lower cost may take many directions. The most rapid progress is likely to result when various technologists and technical skills can be applied. The approach used in the solution of fuels and energy problems at Battelle is described in a new brochure entitled *Battelle Research in Energy and Fuels*. Copies of this brochure are available from the Battelle Publications Office.

# RECENT PAPERS AND ARTICLES BY THE RESEARCH STAFF*

How Economic Factors Influence Materials Selection. Leo C. Bailey and Richard J. Lund. *Materials and Methods*, May, 1953.

Electroplating on Beryllium. John G. Beach and Charles L. Faust. *Journal of the Electrochemical Society*, June, 1953.

Graphitization in Refining Equipment. R. J. Fiorentino and A. M. Hall. *Oil and Gas Journal*, June 8, 1953; *Petroleum Refiner*, May, 1953.

How Well Do Girth Weld Sleeves Resist Loading and Bending Stresses? G. B. Grable and G. M. McClure. *Gas*, June, 1953.

Evaluation of Mold Materials for Titanium Castings. R. M. Lang, J. G. Kura, and J. H. Jackson. American Foundrymen's Society, *Preprint 53-52*, 1953.

The Stress in Large-Diameter Gas-Transmission Pipe. J. S. Lodge and G. K. Manning. American Petroleum Institute, *Proceedings*, 1952.

Preparation and Properties of Iodide Vanadium. Julian W. Nash, H. R. Ogden, Richard E. Durtschi, and I. E. Campbell. *Journal of the Electrochemical Society*, June, 1953.

A Comparison of Zirconium with Better Known Commercial Metals. Arthur D. Schwope. *Metal Progress*, May, 1953.

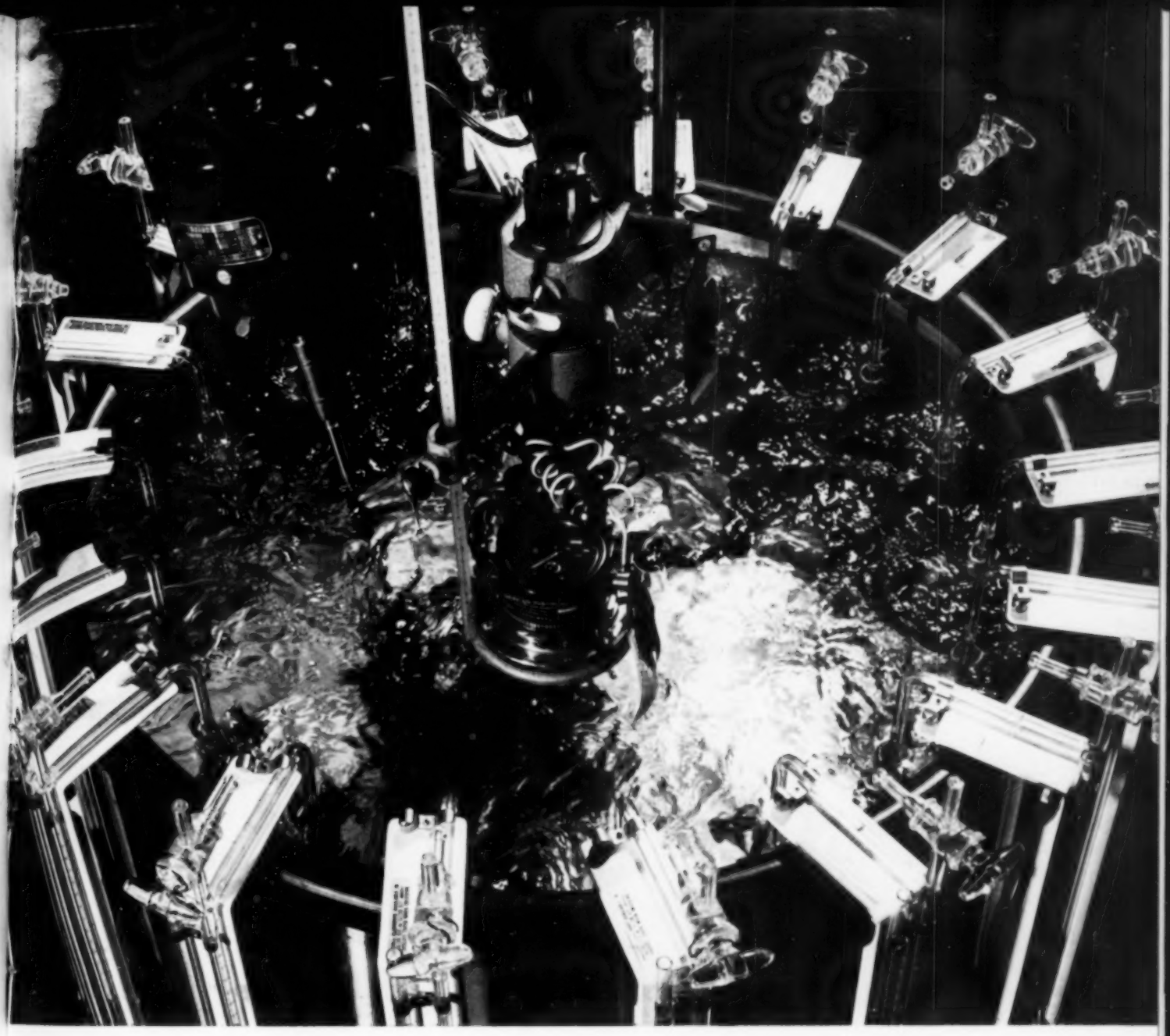
Electroplating on Zirconium. W. C. Schickner, J. G. Beach, and C. L. Faust. *Journal of the Electrochemical Society*, June, 1953.

The Reduction-Oxidation Process for the Treatment of Taconites. F. M. Stephens, Jr., Benny Langston, and A. C. Richardson. *Journal of Metals*, June, 1953.

*In most cases, reprints will be available from the Battelle Publications Office upon request.

## A Word About Battelle Technical Review Abstracts

The abstracts that appear in the following pages are prepared from approximately 1000 American and foreign technical journals, as well as from books and other literature received in the Battelle Library. Prepared by a professional staff trained in various technological fields, the abstracts are selected for their usefulness to the Battelle research staff. They are now being made available to technologists and scientists in industry and research in all parts of the world, through the pages of the *Battelle Technical Review*.



## CATALYST ANALYST

Enzymes are protein catalysts present in all plants and animals, and they play an important part in the growth of living matter. The Warburg equipment enables the biologist to study microscopic quantities of enzymes by measuring the gases given off as a result of their activity. The apparatus can measure gases to one-millionth of a liter and is useful in studies of respiration, oxidation, and certain chemical reactions.

BATTELLE INSTITUTE was founded by the will of Gordon Battelle as a memorial to the Battelle family. The Battelles were among the first settlers of Ohio and were prominent in the development of the state's iron and steel industry.

Gordon Battelle, last of the family line, was impressed with the benefits to be derived from industrial research and left his estate for the building and endowment of an Institute "for the purpose of education . . . the encouragement of research . . . and the making of discoveries and inventions for industry." The Institute began operations in 1929.

As established, Battelle provides, on a not-for-profit basis, the physical plant, equipment, and personnel for conducting research. The great bulk of it is applied research conducted for industry and government.

In keeping with its educational function, the Institute also conducts fundamental or basic research. The results of much of this research are published for the general encouragement of science and industry, and to benefit the public welfare.

Fields of research at Battelle include agriculture and practically all the industrial and engineering sciences.

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